

The TDR, sensitivity, backgrounds and simulations

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- Background suppression
- Background estimates
- Acceptance estimate
- MC studies needed
- FastMC status
- GEANT MC status

“GEANT/RECON” means full reconstruction and analysis of simulated data produced by GEANT.

This morning Evelyn Kennedy Jaffe said, “Please have a short meeting so you can come home to read me stories.”

Background suppression: Photon veto

- Need $\sim 0.3\bar{\epsilon}_{E787}$ at low E_γ or $2\pi^0, 3\pi^0$ background overwhelming (TN083)
- FLUKA MC studies do not agree with E787 measurements
 $E_\gamma = (30 - 225)$ MeV
- Need better MC and/or new measurements

Background suppression: Charge veto

- PSI studies show large light yield in thin counters. If applicable, $\pi\pi\pi^0$ and $K_{e3\gamma}$ backgrounds would be significantly suppressed below current assumptions.
- Timing - initial Japanese efforts with FastMC and DSV not encouraging

Background suppression: Hermiticity and dead material

- Reduction of efficiency due to pipe, tank, support material, cables, etc. is unknown
- Region around beam catcher currently problematic. Solution proposed, but not yet studied or elaborated.

Background suppression: Kinematics

- Effect of overlapping showers on $\bar{\epsilon}(PV)$ calculated. Complete calculation with GEANT/RECON needed.
- FastMC estimates use Zeller's model of PR WC resolution. Are resulting resolutions and efficiencies realistic? Need GEANT/RECON.

Background estimation (all need GEANT/RECON studies)

- $2\pi^0$ Methods unchanged
- $\pi\pi\pi^0$
 - CV Timing
 - Need explicit calculation of small but significant suppression by $\pi^- p \rightarrow \pi^0 n$ or $\pi^- p \rightarrow \gamma n$ and PV
- K_{e3} (0.02 events in TDR). Is it lower due to new CV assumptions?
- $\gamma\gamma$ (0.02 events in TDR). Is γA scattering important?
- $K_{e3\gamma}$
 - CV timing
 - $\epsilon(e^+), \epsilon(\pi^-)$ measurements useful
- $\Lambda \rightarrow \pi^0 n$ negligible

Background estimation continued

- $nA \rightarrow \pi^0 A$
 - 0.2 events in TDR for both γ converting in PR
 - background rate for other configurations? (i.e., 1 γ CAL & 1 γ PR)
- Accidental
 - 0.8 events in TDR
 - Expected rates of 1000, 100, 10 kHz from n, K_L, γ unchanged?
 - Accidental background rates for other configurations?
- K_{e4} Not in TDR. ~ 1 event (my estimate). Need US CV?

Acceptance estimation (need GEANT/RECON studies)

Loss of acceptance since original TDR. Evaluated with FastMC.

(Following items are called “New” in subsequent tables)

- Larger DS hole. $\sim 9\%$ loss
- Decay region 65 cm DS to accomodate collimation, sweeping magnets.
 3% loss.
- Extended target, collimation, angular dependence of K_L beam. $0 \pm 2\%$ loss.

Signal and background rate estimation from FastMC

Cut	Old	New	Old	New
	$K_L^0 \rightarrow \pi^0 \nu \bar{\nu}$	$K_L^0 \rightarrow \pi^0 \nu \bar{\nu}$	Background	Background
MZ	28.87 ± 0.3748	25.76 ± 0.3154	8.911 ± 0.4489	9.655 ± 1.259
AK basic	91.22 ± 0.6632	81.31 ± 0.5576	145.4 ± 3.463	143.4 ± 7.980
AK loose	60.15 ± 0.5394	53.60 ± 0.4531	55.22 ± 2.084	64.09 ± 7.303
AK lominal	53.63 ± 0.5094	47.55 ± 0.4266	35.88 ± 0.7829	41.26 ± 4.025
AK tight	36.98 ± 0.4226	32.79 ± 0.3540	16.80 ± 0.5579	17.00 ± 1.329
AK tighter	24.34 ± 0.3427	21.83 ± 0.2895	7.351 ± 0.3439	6.226 ± 0.2494
AK tightest	21.24 ± 0.3203	18.93 ± 0.2696	5.756 ± 0.3097	5.186 ± 0.2282

Background = $K_L^0 \rightarrow \pi^0 \pi^0 \pi^0$, $K_L^0 \rightarrow \pi^0 \pi^0$, $K_L^0 \rightarrow e^\pm \pi^\mp \nu \gamma$ & $K_L^0 \rightarrow \pi^0 \pi^+ \pi^-$
 $(\pi^0 \gamma \gamma$ for new only, < 0.3 events) only.

2γ conversions in PR only. No reoptimization of cuts for “New” rates.

$K_L^0 \rightarrow \pi^0\pi^0$ and $K_L^0 \rightarrow \pi^0\pi^0\pi^0$ rate estimation from FastMC

Cut	Old		New	
	$K_L^0 \rightarrow \pi^0\pi^0\pi^0$	$K_L^0 \rightarrow \pi^0\pi^0\pi^0$	$K_L^0 \rightarrow \pi^0\pi^0$	$K_L^0 \rightarrow \pi^0\pi^0$
MZ	1.001 ± 0.3574	1.947 ± 0.9727	3.715 ± 0.1485	3.899 ± 0.7853
AK basic	1.891 ± 0.3867	2.985 ± 0.9966	110.3 ± 3.379	109.6 ± 7.906
AK loose	0.8845 ± 0.06686	2.146 ± 0.9742	45.24 ± 2.055	53.43 ± 7.234
AK lominal	0.8843 ± 0.06686	2.146 ± 0.9742	26.74 ± 0.7125	31.35 ± 3.899
AK tight	0.6664 ± 0.06446	1.929 ± 0.9739	10.02 ± 0.4826	9.680 ± 0.8856
AK tighter	0.4500 ± 0.05326	0.3694 ± 0.03991	3.176 ± 0.2626	2.380 ± 0.1970
AK tightest	0.4031 ± 0.05228	0.3404 ± 0.03974	2.370 ± 0.2388	1.758 ± 0.1747

$K_L^0 \rightarrow e^\pm \pi^\mp \nu \gamma$ and $K_L^0 \rightarrow \pi^0 \pi^+ \pi^-$ rate estimation from FastMC

Cut	Old		New	
	$K_L^0 \rightarrow e^\pm \pi^\mp \nu \gamma$	$K_L^0 \rightarrow e^\pm \pi^\mp \nu \gamma$	$K_L^0 \rightarrow \pi^0 \pi^+ \pi^-$	$K_L^0 \rightarrow \pi^0 \pi^+ \pi^-$
MZ	3.536 ± 0.2103	3.007 ± 0.1330	0.6595 ± 0.08657	0.7203 ± 0.05313
AK basic	17.34 ± 0.5010	15.17 ± 0.3391	15.89 ± 0.4141	15.35 ± 0.2456
AK loose	6.856 ± 0.2972	6.195 ± 0.2043	2.233 ± 0.1597	2.164 ± 0.08806
AK lominal	6.031 ± 0.2747	5.508 ± 0.1914	2.228 ± 0.1596	2.142 ± 0.08771
AK tight	4.679 ± 0.2398	3.999 ± 0.1630	1.437 ± 0.1291	1.311 ± 0.06786
AK tighter	3.028 ± 0.1934	2.715 ± 0.1349	0.6971 ± 0.09529	0.6947 ± 0.05023
AK tightest	2.542 ± 0.1757	2.464 ± 0.1291	0.4408 ± 0.07297	0.5589 ± 0.04695

MC studies needed: Background

- Interbunch extinction
- Bunch width
- Neutron background for potential acceptance increases (next page)
- Accidental rates for potential acceptance increases
- Loss of efficiency due to inactive material
- $\pi\pi\pi^0$ and CV timing
- $K_{e3\gamma}$ and CV timing
- $\gamma\gamma$ and interactions
- $2\pi^0$ Overlapping showers (GEANT only)
- Low energy photon veto

MC studies needed: Acceptance

- $> 1K_L/\mu\text{bunch}$
- Self-vetoing (GEANT only)
- Reconstruction efficiency (GEANT only)
- Loss of efficiency due to inactive material
- 1γ CAL & 1γ PR
- 1γ BV & 1γ PR
- 1γ OV & 1γ PR
- 2γ PR/OV (no γ in CAL)

MC studies needed: Other

- CV in US beam pipe?
- How close should (can) barrel CV be to beam?
- Where to place high/low vacuum membrane(s)?
- MWPC CV at front of PR? At end of CAL? Is D4 needed?
- Move catcher US?
- DSV3 design and positions?
- Losses due to instrumentation failure?

FastMC status: Brief description

- Simple geometry: all volumes are rectangular parallelopipeds
- No magnetic fields
- “Zeller” PR model used for studies in this talk
- Hermiticity assumed
- $\bar{\epsilon}_{\text{PV}}(E_\gamma)$ or $\bar{\epsilon}_{\text{PV}}(\text{catcher})$ for photon veto assumed
- $\bar{\epsilon}_{\text{CV}}(E, \text{species})$ for charged veto assumed.
- Veto timing ignored thus far.
- Standard veto inefficiencies in FastMC have not changed since TDR.

FastMC status: Recent upgrades

- Larger downstream beam hole (done)
- Move decay region from (950,1350) to (1015,1415) cm (done)
- Angular dependence of K_L^0 beam (done)
- Extended target (done)
- Position-dependent $\bar{\epsilon}_{PV}(E_\gamma)$ from GEANT (difficult)
- Incorporate BV and/or OV resolutions (need model)
- **Still need to re-optimize cuts**

FastMC study of CV timing

Duplicates some of FastMC studies by Tadashi Nomura:

http://pubweb.bnl.gov/users/e926/www/meetings/DCV/jul18_03/20030718.DCPV_MC.pdf

http://pubweb.bnl.gov/users/e926/www/meetings/DCV/oct10_03/20031011.DCPV_MC.pdf

Assumptions:

1. Rectilinear geometry only, no magnetic fields
2. Assume charged tracks stopped by D4 at 200cm from front of PR
3. Perfect position and time resolution for CV

Timing variable is $dtdx = T_i - T(K_L^0) - |\vec{x}_i - \vec{x}_{K_L^0}|/\beta_{\max}c$

T_i, \vec{x}_i = time and impact position of charged track at CV

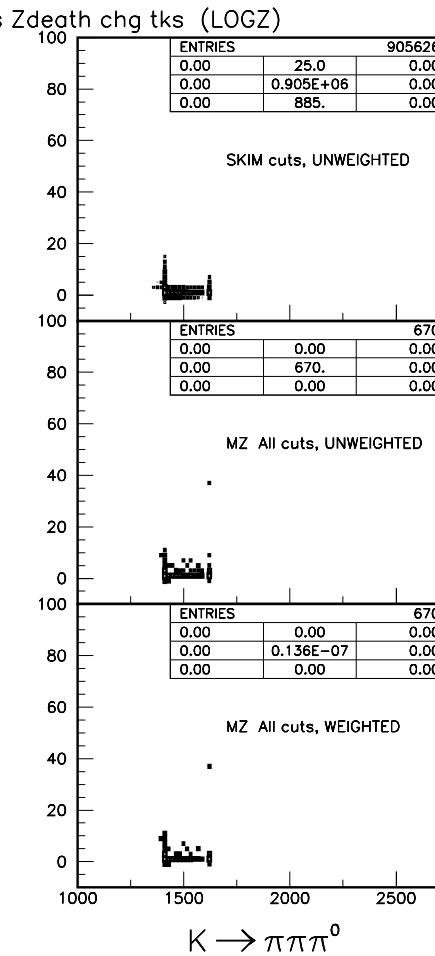
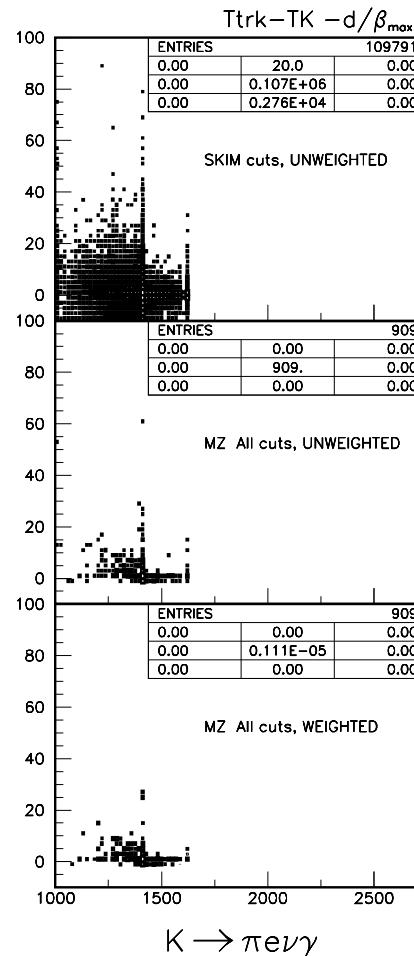
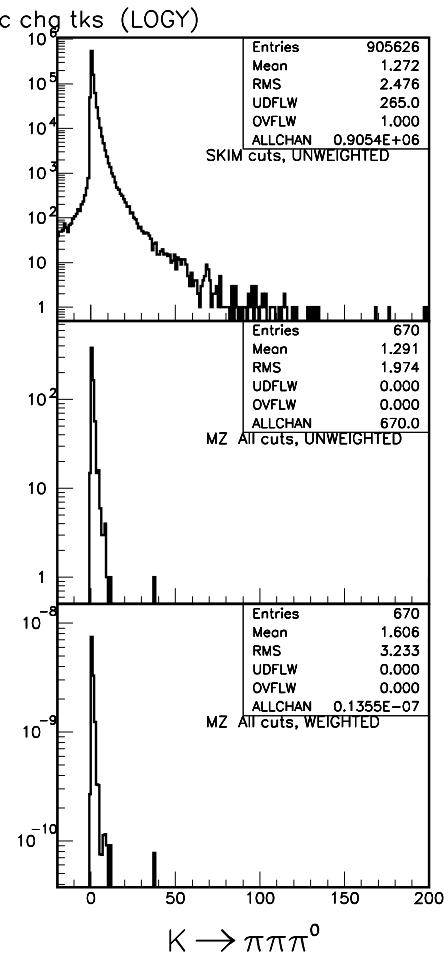
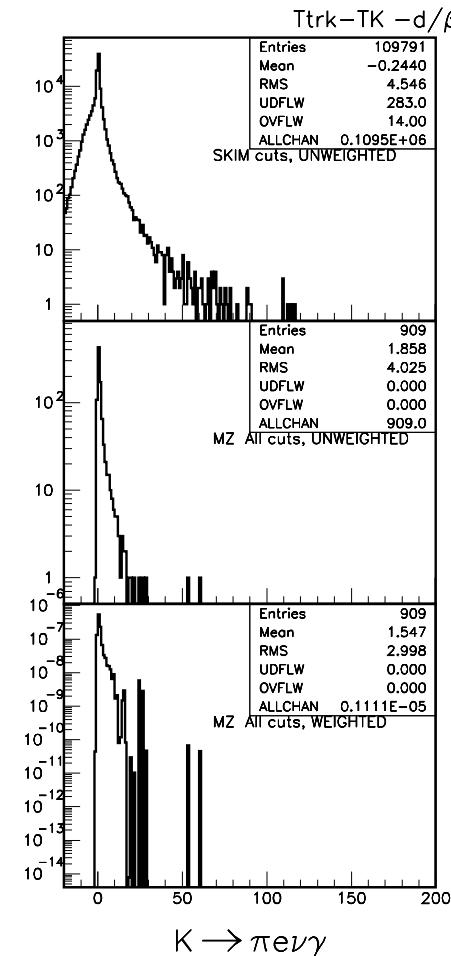
$T(K_L^0), \vec{x}_{K_L^0}$ = reconstructed time and position of K_L^0 decay vertex

$\beta_{\max} = \beta$ assuming $E(\text{kinetic}) = E(K_L^0) - E(\pi^0) - m(\pi^+)$ (Tadashi had a better estimate.)

FastMC study of CV timing: $K_L^0 \rightarrow e^\pm \pi^\mp \nu \gamma$ and $K_L^0 \rightarrow \pi^0 \pi^+ \pi^-$

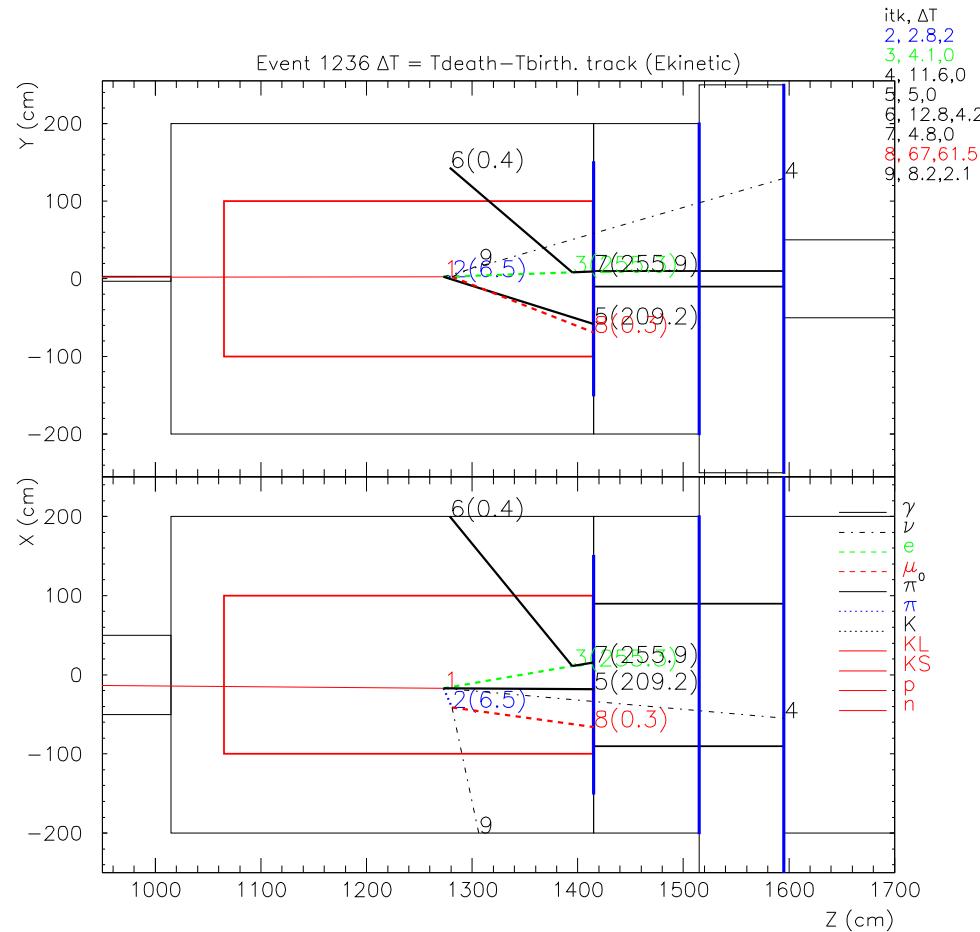
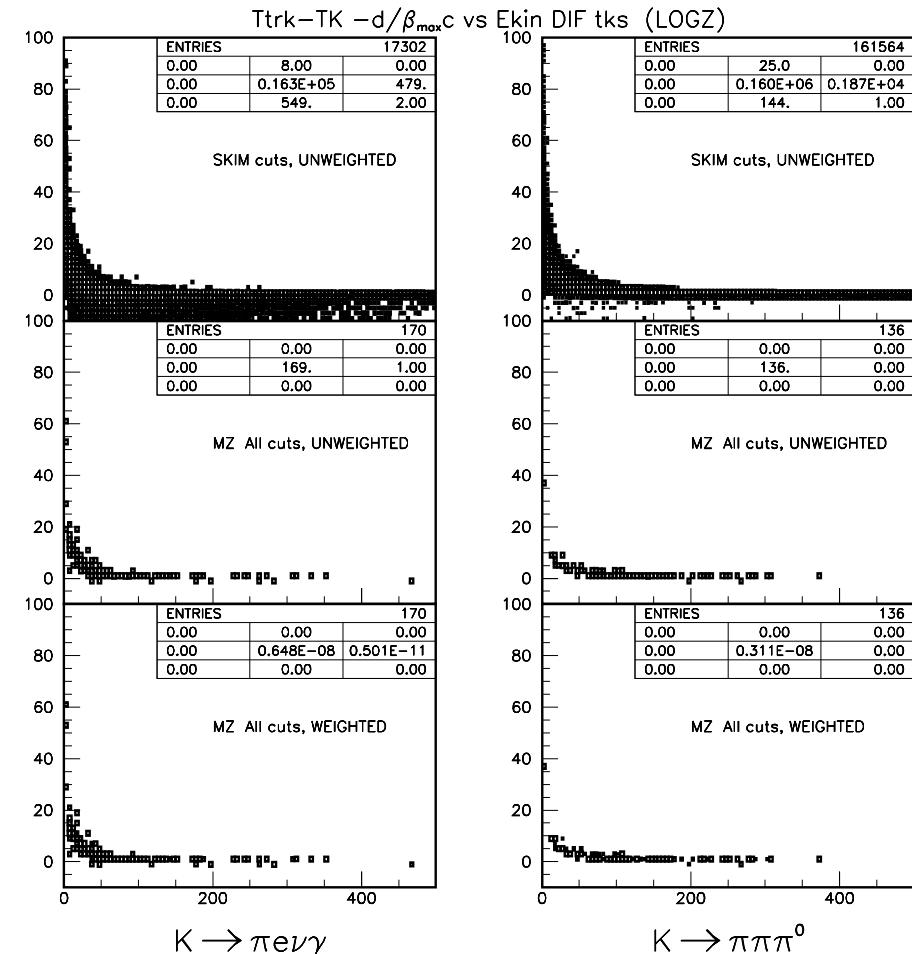
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**dtdx (ns)****dtdx (ns) vs Z(trk) (cm)**

FastMC study of CV timing: $K_L^0 \rightarrow e^\pm \pi^\mp \nu \gamma$ and $K_L^0 \rightarrow \pi^0 \pi^+ \pi^-$

2004/04/23 10.42



$K_L^0 \rightarrow e^\pm \pi^\mp \nu \gamma$ FastMC event display. $E(\text{kin}) = 300$ keV for μ^-

$dtdx$ (ns) vs $E(\text{kin})$ MeV for DIF

FastMC study of CV timing: Observations

1. Large fraction of $dtdx > 20$ ns have DIF (5 of 5 $K_L^0 \rightarrow \pi^0\pi^+\pi^-$ events, double DIF for 2 of 5 $K_L^0 \rightarrow \pi^0\pi^+\pi^-$, 5 of 8 $K_L^0 \rightarrow e^\pm\pi^\mp\nu\gamma$ events)
2. CV as close as possible to K_L^0 decay vertex reduces $dtdx$ (Duh!)
3. MWPC CV at front of PR would help
4. Moving barrel CV closer to beam envelope would help
5. More clever formulation of $dtdx$ would probably help
6. Higher statistics needed, but this sample contained candidates with $dtdx > 40$ ns that would be very difficult, if not impossible, to veto even with closer CV for both $K_L^0 \rightarrow \pi^0\pi^+\pi^-$ and $K_L^0 \rightarrow e^\pm\pi^\mp\nu\gamma$.

GEANT MC status (version v07_4)

PR	OK
CAL	Good
BC	Good
BPV	OK (Rectangular geom. only, no cylindrical geom)
US CV	Unrealistic
BCV	Unrealistic
DSV1	Unrealistic
DSV2	OK
DSV3	Flexible but current positions unrealistic
OV	OK, probably unrealistic
Gap between DSV3 and BC	
No MWPC CV	

GEANT MC status (continued)

n, K_L Good

Collimation Good

B fields Good

Beam pipes, decay tank exist, are they realistic?

Digitization None

Reconstruction None

Digitization & parametrization models

- Predigitization
- KOPTICS or similar for γ propagation in scintillator
- CAL shashlyk - model exists, not yet implemented
- PR WC - simple model exists, not yet implemented

GEANT/RECON model

GEANT produces **ntuple** of digitized data and **geometry file** for input to
ROOT.

Geometry, detector response parametrization and user control are “inputs” to
GEANT

ROOT does unpacking, calibration and reconstruction and produces
ntuple and **Tree** for final analysis with PAW or ROOT, respectively.

Current scheme for **ROOT** is that unpacking and calibration provides
“atomic” analysis units such as time, energy, WFD array for a given detector
element that can be requested by reconstruction.

Fortran/PAW: **GEANT** and **ntuple**

C++/ROOT: **ROOT** and **Tree**

Status of writing - schedule for outline, drafts, etc

I have written nothing new specifically for the TDR.

Current text can be updated and modified incrementally until it needs to go out (when?).

Conclusion

Lots of work to do.

More manpower needed to

- perform studies,
- modify existing simulations,
- develop reconstruction algorithm,
- allow me to read stories to Evelyn.